XXXIV.—*On Recent Contributions to the Classification of the Lepidoptera by Prof. J. H. Comstock* and Dr. T. A. Chapman* †.

Prof. Comstock's discovery of the method of uniting the fore and hind wings in the Hepialidæ and Micropterygidæ by means of what he terms a "jugum," and that the same organ exists in the Trichoptera, is of the greatest interest to entomologists. This jugum consists of a membranous lobe from near the base of the underside of the fore wing, holding the base of the costa of hind wing as in a vice, between it and the inner margin of the fore wing. In most of the other families of Lepidoptera the wings are united by the frenulum, a strong bristle, single in the male, usually multiple in the female, arising from the base of the costa of the hind wing and articulating with the retinaculum on the underside of the fore wing, which generally consists, in the male, of a membranous bar or plate from below the costa or a fold of the costa itself, in the female of a tuft of hair from the median nervure. In many families and genera, however, the frenulum has become aborted and an expansion of the costa of the hind wing prevents the displacement of the wing. The frenulum originally consisted of a tuft of hair, and retains its primitive form in some female Cossidæ and other lowly organized forms, but in most moths has been developed into three strong bristles in the female and a compound single bristle in the male; though in the Noctuid genus *Stictoptera* and in the Phycitinæ it is single in both sexes, in the latter—a subfamily of the Pyralidæ—the retinaculum, in both sexes, consisting of a tuft of hair from the median nervure.

That the Hepialidæ and Micropterygidæ are widely separated from all the other families of Lepidoptera has long been recognized by reason of their having twelve veins to the hind wing as in the fore wing, no other family having more than eight; but that they are closely related to each other has been constantly denied, owing to the great difference in form and size and the existence of highly developed biting mouth-parts in the Micropterygidæ, whilst in the Hepialidæ the proboscis and usually the palpi are wanting; so that the discovery of a specialized common structure in the jugum is a fact of great importance.

* J. H. Comstock, "Evolution and Taxonomy," Wilder Quarter Century Book, Ithaca, N. Y., 1893, pp. 37–113.

† T. A. Chapman, Trans. Ent. Soc. 1893, p. 97, and 1894, p. 335.

On the other hand, the Micropterygidæ have often been compared with the Trichoptera, owing to their resemblance in form and structure; and the discovery of the jugum being common to the two groups should go far to prove the derivation of the Lepidoptera from the Trichoptera, and to disprove the alternative theory of a Hymenopterous ancestor based on the resemblance between the larvæ of Lepidoptera and of sawflies.

Dr. Chapman's discovery of the larva of the lower of the two Micropterygid genera—*Eriocephala*—with its antennal and anal appendages, complete set of legs to each somite, spiculate tubercles, and abdominal sucker, tends to complete our knowledge of the group.

After dividing the Lepidoptera into Jugatæ and Frenatæ, Prof. Comstock proceeds to subdivide the latter into families which retain the frenulum and others that lose it; but this is certainly not a natural arrangement, as the loss of the frenulum occurs in scattered genera in many families of Lepidoptera, such as:—*Himantopterus* in the Zygænidæ; the Arbelidæ, closely allied to the Cossidæ; *Cleosiris* in the Callidulidæ; many genera of Drepanulidæ, such as *Phalacra*, *Drapetodes*, *Oreta*, and *Cilix*; *Ratarda* in the Lymantriidæ; the Uraniidæ, nearly related to the frenulated Epiplemidæ; and in the Geometridæ, *Hypulia* and *Genusa* in the Boarmiinæ, and many genera of Geometrinæ.

Prof. Comstock again subdivides his groups by the reduction of the inner area of the fore and hind wings, after doing which he leaves his other families undefined till he completes his study of them. But it is not correct to talk, as he does, of the reduction of the inner area; it is vein 1 *c*, not vein 1 *a*, that becomes aborted in each wing, and it is only in such families as the Saturniidæ, Endromiidæ, Drepanulidæ, and Geometridæ, where vein 1 *a* terminates on the inner margin before the anal angle or is absent altogether, that the inner area of the hind wing is somewhat reduced. The inner area of the fore wing, on the other hand, is somewhat extended by the migration of the subcostals, carrying with them the cell from its original medial position, towards the costa in order to strengthen that margin for purposes of flight—the subcostal nervules becoming crowded close together and their combinations more complex and liable to vary, and characters based on them consequently of less value in the higher than the lower forms.

That the primary division of the Frenatæ into "frenulum losers" and "frenulum conservers" is faulty is recognized by

Mr. H. G. Dyar *, who has worked out Prof. Comstock's system in relation to the setiferous tubercles of the larvæ; and it seems to me that a better primary character is to be found in the migration of vein 5 of the fore wing from its original position at the middle of the discocellulars towards either the lower or upper angles of the cell, as used by myself in my 'Moths of India' †. This, indeed, is practically admitted by Prof. Comstock himself, for he says, at p. 45 of his paper :—

"The loss of the frenulum in certain Frenatæ renders necessary the use of some other character or characters by the systematists as recognition characters."

And at p. 89 :—"And in the Drepanidæ, where the frenulum is usually wanting, it persists in one sex in certain genera." It would be more correct, however, to say that the frenulum is usually present in both sexes, but wanting in several genera. Whilst of vein 5 of the fore wing he says at p. 76 :—

"The union of vein V_1 [vein 6] with radius [the subcostal nervure] and of vein V_3 [vein 4] with cubitus [the median nervure] after the abortion of the base of the media [the radials] is what would be expected. But in which direction would one expect the base of vein V_2 [vein 5] to migrate? Occupying an intermediate position between radius and cubitus, it may go either way. It is like a stream in the middle of a level plain, a trifle may change its course. And thus we find that in some families it migrates towards the cubitus, making this vein apparently four-branched, whilst in other families it goes towards the radius, leaving cubitus apparently three-branched. This difference may be looked upon as a difference in kind of specialization, and is frequently of high value as indicating a *dichotomous division* of the line of descent. It is obvious that in a family where vein V_2 has migrated far towards cubitus, and has thus established its chief source of air-supply in that direction, it is not probable that genera will arise in which vein V_2 is more closely united to radius than to cubitus. To resume the figure, the plain through which the stream is flowing is an elevated plateau, a pebble may determine which of two slopes it shall descend, but when started down one it cannot traverse the other."

A more curious instance of the failure to apply his own principles is to be found on pp. 97, 98, and 108, where the Zygænidæ are divided into two sections falling into widely

* Ann. N. Y. Acad. Sci. viii. p. 202.

† 'Moths of India,' vol. i. p. 9 (1893).

separated groups of families: the first section, as a matter of fact, being the Syntomidæ, erected as a family first by Herrich-Schäffer in 1845, dominant in America but poorly represented in the Old World, and closely related in the form of larvæ and pupæ, as shown by Dr. Chapman, to the Arctiidæ; whilst the second section, the Zygænidæ proper, hardly represented in America but numerous in the Old World, is related, as Dr. Chapman has also shown, to the Limacodidæ and the lowest families of the Frenatæ; these relationships of the two families being fully borne out by the structure of the imago.

One of the many points of interest in Prof. Comstock's paper is his confirmation of the fact that vein 4 is really a part of the three-branched radial nervure, its connexion with the two-branched median nervure being only secondary, as Spuler * first demonstrated from a study of its development.

The suggestion of the relationship of the Hesperiidæ to the Thyrididæ is interesting, and is based on the origin of veins 6 to 11 of the fore wing directly from the cell, which is a character common in the lowest Frenatæ, such as the Zygænidæ and Sesiidæ. The small Oriental day-flying family—the Callidulidæ—akin to the Thyrididæ, has some forms which are so like the Hesperiidæ in flight and general appearance as to be indistinguishable on the wing. In the Callidulidæ and Thyrididæ, however, vein 5 of the fore wing has migrated to the lower angle of the cell, whilst in the Hesperiidæ it arises near the middle of the discocellulars—from slightly above or below—so that it would be from some ancestral form before the migration of vein 5 became fixed, and not from the Callidulidæ themselves, that the development took place. Again, in the Thyrididæ and Callidulidæ vein 8 of the hind wing approaches vein 7 after its origin from the cell, whilst in the Hesperiidæ they are widely separate, though in the Callidulid genus *Herimba* there is an approach to the Hesperid form, this genus being also of interest from the retinaculum of the male consisting of a tuft of hair from the median nervure of fore wing, which is the usual female form. In the Hesperiidæ also this tuft of hair is often developed, and to a certain extent articulates with rough hair from the costa of the hind wing, possibly representing the primitive form of the frenulum. In other Callidulidæ the frenulum is entirely absent, whilst the Australian *Euschemon Rafflesia*, Westw., is a typical Hesperid in every point of

* A. Spuler, 'Zur Phylogenie und Ontogenie des Flügelgeäders der Schmetterlinge.'

structure except in the possession of a fully developed frenulum and retinaculum.

Dr. Chapman's contributions to the classification of the Lepidoptera are entirely derived from a study of the early stages, more especially the segments of the pupæ. He shows that in most of the families of what are usually termed Macro-Lepidoptera, and also in the Pyralidæ and some of the higher subfamilies of the Tineidæ, the movable segments of the pupæ are the fifth and sixth abdominal in both sexes, that they have no power to emerge (as pupæ) from the cocoon, and that dehiscence on the emergence of the imago is by irregular fracture. On the other hand, in all the lower families of the Micro-Lepidoptera the pupa is much less solid, the appendages often partially free, the free segments may extend to the third abdominal, and the seventh segment is always free in the male, fixed in the female. Also that dehiscence is accompanied by freeing of the segments and appendages previously fixed, and that the pupa has the power of progression and emerges from the cocoon, except in the Pterophoridæ. And he proves that the Sesiidæ, Psychidæ, Cossidæ, Hepialidæ, Zygænidæ, and Limacodidæ belong to this lower group of families, in which he is entirely supported by the structure of the imago.

The following key is intended to summarize our present knowledge of the relationships of the various families of Lepidoptera, the minor distinctions which are in general use being omitted, and the families numbered from the bottom upwards in what seems to be the most natural order of arrangement:—

A. Hind wing with 12 veins as in the fore wing and united to the fore wing by a jugum ..... 1. *Micropterygidæ*. 2. *Hepialidæ*.

B. Hind wing with not more than 8 veins and retained in position by a frenulum or an expansion of the base of the costa.

Fore wing with vein 1 *c* present.

3. *Limacodidæ*. 4. *Zygænidæ*.
5. *Castniidæ*. 6. *Megalopygidæ*.
7. *Psychidæ*. 8. *Heterogynidæ*.
9. *Cossidæ*.

Fore wing with vein 1 *c* absent *.

Fore wing with vein 5 from the middle of the discocellulars, the other veins given off from the cell arising at nearly even distances on each side of it.

13. *Sesiidæ*. 14. *Tineidæ*.
15. *Alucitidæ*. 16. *Pterophoridæ*.

* Except in some genera of Tineidæ, such as *Methypsa* and *Tortricomorpha*.

Fore wing with vein 5 arising much nearer 4 than 6.

Hind wing with vein 8 curved and nearly or quite touching 7, or connected with i by a bar after its origin from the cell.

17. *Pyralidæ.* 18. *Thyrididæ.*
19. *Drepanulidæ.* 20. *Callidulidæ.*
11. *Lasiocampidæ.*

Hind wing with vein 8 remote from 7 after its origin from the cell ..... 10. *Arbelidæ.* 12. *Endromiidæ.*
21. *Syntomidæ.* 22. *Arctiidæ.*
23. *Lymantriidæ.* 24. *Pterothysanidæ.*
25. *Hypsidæ.* 26. *Agaristidæ.*
27. *Noctuidæ.*

Fore wing with vein 5 from the middle of the discocellulars or nearer 6 than 4 *, the veins not arising at even distances round the cell ..... 28. *Cymatophoridæ.* 29. *Sphingidæ.*
30. *Notodontidæ.* 31. *Dioptidæ.*
32. *Geometridæ.* 33. *Epiplemidæ.*
34. *Uraniidæ.* 35. *Epicopeidæ.*
36. *Bombycidæ.* 37. *Eupterotidæ.*
38. *Ceratocampidæ.* 39. *Brahmæidæ.*
40. *Saturniidæ.* 41. *Rhopalocera.*

After the development of the Frenatæ we may picture the ancestor of all this group of families of Lepidoptera to have been a form with a frenulum, the fore wing with vein 1 *c* present, veins 2 to 11 given off at regular intervals round the cell, the hind wing with eight veins, 1 *a*, *b*, *c*, all present, vein 8 free from the base, but connected with the cell by an oblique bar, the remains of one of the lost subcostals, and the forked stalk of the radial vein still present in the cell of each wing—a form which almost exactly survives in some of our present Zygænidæ and Cossidæ, and to which families 3 to 9 are all closely allied. From this Zygæno-Cossid form has arisen :—

I. Through *Alavona*—the Tineidæ, Pterophoridæ, and Alucitidæ, by the loss of vein 1 *c* of the fore wing and of the oblique bar connecting vein 8 with the cell of hind wing; and, as a further development, the Sesiidæ, by the loss of vein 8 of the hind wing.

II. The families in which, besides the loss of vein 1 *c* of the fore wing, vein 5 has migrated towards the lower angle of the cell, the bases of some of the subcostals of the fore wing usually becoming united.

(1) The Arbelidæ, Endromiidæ, and Lasiocampidæ, by the loss of the frenulum; the bar between vein 8 and the cell

* Except in some genera of Dioptidæ.

of hind wing being retained, or vein 8 being united to 7 after its origin.

(2) The Pyralidæ, Thyrididæ, Drepanulidæ, and Callidulidæ, by the loss of the bar, vein 8 bending down and becoming connected with 7 after its origin; the frenulum in the last two families being often lost.

(3) The Hypsidæ and Lymantriidæ, retaining the frenulum and the bar between vein 8 and the cell of hind wing.

(4) The Pterothysanidæ, by the loss of the frenulum and the freeing of vein 8 of hind wing.

(5) The Syntomidæ, by the loss of vein 8 of hind wing.

(6) The Arctiidæ, by the coalescence of vein 8 of hind wing with the cell to a greater or less degree.

(7) The Noctuidæ and Agaristidæ, by vein 8 being connected with the cell at a point near the base only.

III. The forms where vein 1 *c* of fore wing is lost, but vein 5 retains its position at the middle of the cell or has migrated towards the upper angle.

(1) The Dioptidæ, in which vein 5 of the fore wing has not become fixed, for whilst it retains its medial position in most forms, in some it has migrated to the lower angle of the cell, vein 8 of the hind wing being free.

(2) The Geometridæ, in which vein 5 often migrates towards the upper angle of cell; vein 8 of the hind wing retains the bar in the lowest subfamily, Orthostixinæ, anastomoses strongly with the cell in the Larentiinæ, becomes quite free except near the base in the Acidaliinæ and Geometrinæ, and entirely free but closely approximate to the cell in the Boarmiinæ, the lowest forms of which, however, *Abraxas* and its allies, often retain the bar; in many genera the frenulum becomes aborted.

(3) The Epiplemidæ and Epicopeidæ, in which vein 8 becomes quite free and widely separated from the cell, the latter having the frenulum rudimentary.

(4) The Uraniidæ, Bombycidæ, Ceratocampidæ, Saturniidæ, and Brahmæidæ, in which the frenulum is lost, vein 8 being entirely free except in a few forms of the Bombycidæ, where the bar is retained, and in *Brahmæa*, where it becomes closely connected with 7.

(5) The Eupterotidæ, in which both the bar and the frenulum are retained.

(6) Whilst branching off in another direction from the ancestor of this group were developed the Notodontidæ, which retain the bar in the lower forms from which arose the Sphingidæ, retaining the bar and with vein 8 closely connected

with 7, and the Cymatophoridæ, in which the bar is lost and vein 8 anastomoses with 7.

(7) The Rhopalocera, which have lost the frenulum, but in some of the lower forms of which traces of vein 1 *c* and the stalk of the radial vein are retained; vein 5 of the fore wing is given off either above or below the middle of the disco-cellulars, and vein 8 of the hind wing has become entirely free. In the lowest family—the Hesperiidæ—the subcostals of the fore wing are all given off from the cell, the union of their bases only occurring in the higher families.

G. F. Hampson.

XXXV.—*On some Small Collections of Odonata (Dragonflies) recently received from the West Indies.* By W. F. Kirby, F.L.S., F.E.S., Assistant in Zoological Department, British Museum.

The British Museum has recently received some collections of insects of various orders from the West-Indian Exploration Committee. Among these were nineteen species of Dragonflies which were collected by Mr. H. H. Smith in St. Vincent and Grenada, an account of which is furnished in the present paper. Four species have been described as new, one of which is regarded as the type of a new genus, while two or three others are new to the collection of the British Museum; and two specimens, probably new, but belonging to obscure and imperfectly known groups, are left undetermined for the present, the material at hand being insufficient for their elucidation.

The whole of the information which accompanied them is here published, being placed between inverted commas. About nineteen species were received, belonging exclusively to the subfamilies Libellulinæ and Cœnagrioninæ.

The species described as new are as follows:—

Brechmorhoga (g. n.) *grenadensis.*
Dythemis multipunctata.
Cannacria Smithii.
Micrathyria (?) *pruinosa.*

All these belong to the Libellulinæ.